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# THE J- CURVE DYNAMICS OF SOUTH AFRICAN TRADE: EVIDENCE FROM THE ARDL APPROACH

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## Abstract

This paper assesses the behaviour of South Africa's trade balance following a depreciation of the real effective exchange rate (the J-curve phenomenon) using aggregate trade data for the period 1975 to 2011. It uses the bounds test approach to cointegration developed by Pesaran *et al*. (2001) to analyze the long-run relationship among the variables. The empirical results indicate thatthere is cointegration between the trade balance and the real effective exchange rate, and domestic and foreign income. Our long-run results indicate that the real effective exchange rate carries a negative sign but is statistically insignificant.Although our short-run result shows evidence for negative values in earlier quarters followed by positive values later as the lag length increases, most of the coefficients are insignificant. Therefore we do not find support for the J-curve phenomenon

**Keywords:** Bounds test, Trade balance, J-curve, real depreciation, South Africa

## Introduction

The Marshall-Lerner condition says that currency devaluation may only succeed in improving the trade balance of a country in the long-run if the sum of export and import elasticities is greater than unity. This line of reasoning comes from the elasticities approach to the balance of payments. This approach argues that due to currency devaluation, exporters earn more money in domestic currency terms while importers pay more in domestic currency terms for any given level of imports. Thus, currency devaluation(depreciation) is expected to encourage exports and discourage imports, thereby improving the trade balance. However, the changes in the volumes of exports and imports may not be instantaneous, hence the short-run deterioration in the trade balance.

The real exchange rate depreciation is believed to produce an improvement in the trade balance in the long-run after a short-run deterioration. It is this real exchange rate effect on the trade balance that is referred to as the J-curve. This phenomenon was first observed by Magee (1973). Magee (1973) attributes the causes of the J-curve to three adjustment periods: currency contract period, pass-through period, and the sluggish response period. Junz and Rhomberg (1973) explain the delayed effect of the real exchange rate on the trade balance in terms of five adjustment lags. These are the recognition lag of changed situation, decision lag to change real variables, delivery lag, replacement lag of inventories and materials, and the production lag.

The relationship between currency devaluation (depreciation) and trade balance (the J-curve phenomenon) has been extensively investigated in both developed and developing countries using different econometric techniques and models. Analyses have been done at different levels. Some studies used aggregate data (Hacker and Hatemi, 2004; Halicioglu, 2008). Others used bilateral trade data (Marwah and Klein, 1996; Wilson, 2001; Perera, 2009). Other studies used industry level trade data (Bahmani-Oskooee and Mitra, 2009). The empirical results of these studies are mixed (Perera, 2009). Most of these studies are on developed countries and developing countries from other parts of the world apart from Africa. For African countries the literature is still growing (see Bahmani-Oskooee and Gelan 2012; Bahmani-Oskooee and Hosny, 2013; Umoru and Eboreime, 2013; and Abd-El-Kader, 2013). The results from those studies which have considered South Africa are mixed.

The current study tries to contribute to the growing literature on the African continent by examining the relationship between trade balance and the real effective exchange rate for South Africa, using aggregate data for the annual period 1975 to 2011.This paper seeks to answer two specific questions: First, is there a long-run relationship between the trade balance and the real effective exchange rate? Second, does the J-curve effect exist for South Africa? To answer these research questions we adopt the partial and reduced form model of Rose and Yellen (1989) and then employ the autoregressive distributed lag (ARDL) bounds testing approach to cointegration which was advanced by Pesaran *et al*. (2001).

The rest of the paper is structured as follows.Section 2 gives an overview of the empirical literature on African countries. In section 3 we present the theoretical framework for the J-curve. In section 4 we present the general econometric methodology used in this study. Our empirical results are presented in section 5. Section 6 concludes the paper.

## An overview of the African empirical literature

To the best knowledge of the authors the earliest study on the J-curve on South Africa is by Kamoto (2006). This particular study tests the J-curve hypothesis in the cases of Malawi and South Africa. The study uses quarterly data for the period 1976 to 2003. The trade balance is defined as the ratio of a country's exports to imports. The study models trade balance as a function of real effective exchange rate, domestic and foreign incomes. The GDP for the United States of America is used as a proxy for world income. The long-run relationship among the variables is tested using the Johansen approach.

The study's results indicate a positive long-run relationship between trade balance and the real effective exchange rate in both Malawi and South Africa. Domestic (foreign) income is found to have a long-run positive (negative) in the case of South Africa. This finding suggests that the influence of domestic and foreign incomes on the South African trade ratio maybe supply driven. For Malawi the long-run impacts of domestic and foreign incomes are negative and positive, respectively. This finding is consistent with economic theory when demand is expected to dominate.The study's empirical results about the generalized impulse response functions suggest that only South Africa supports the J-curve hypothesis.

Moodley (2010) examines the J-curve hypothesis on South Africa's bilateral trade with the BRIC countries (Brazil, Russia, India, and China) over the period 1994Q1to 2009Q4. The study employs the autoregressive distributed lag approach to assess the long-run relationship among the variables in the trade balance model (namely, trade balance, real exchange rate, and domestic and foreign incomes). The study finds mixed results on the impact of the real exchange rate on the trade balance. For Brazil and India the real exchangerate has a negative impact while for Russia and China it is found to have a positive impact. The author concludes that devaluation does not necessarily lead to a long term improvement of the trade balance and therefore no evidence of the J-curve was found.

Bahmani-Oskooee and Gelan (2012)test the J-curve hypothesis for nine African countries (Burundi, Egypt, Kenya, Mauritius, Morocco, Nigeria, Sierra Leone, South Africa, and Tanzania). The authors use quarterly data for the period 1971Q1 to 2008Q4. They define the trade balance as the ratio of each country's imports to exports. The study uses the bounds testing approach to cointegration and error-correction modelling. Their results of the short-run indicate that at 10% level of significance there is at least one coefficient of the differenced real effective exchange rate that is significant in the cases of Burundi, Egypt, Mauritius, Nigeria, and Tanzania. These short-run effects translate into significant long-run positive effects in the results for Egypt, Nigeria, and South Africa. This finding suggests that a real depreciation is expected to improve the country's trade balance in the long-run. In the remaining countries the long-run coefficient for the real effective exchange rate is insignificant or negative. Their study does not find support for the J-curve in all countries.

Umoru and Eboreime (2013) examine the J-curve hypothesis for the Nigeria oil sector for the period 1975 to 2009. The study employs the ARDL bounds testing approach. The authors define real oil trade balance as the difference between oil exports and the bilateral imports value between Nigeria and the United States of America in constant 1984 prices. The study finds no evidence in support of the J-curve on the trade balance of the Nigerian oil sector.

Abd-El-Kader (2013) tests the J-curve hypothesis between Egypt and her twenty major trading partners using bilateral trade data for the period 1989 to 2010. The main finding of the study is that the real exchange rate variations explain a considerable part of the trade balance change in Egypt. The study's results indicate that, in the short-run, depreciation deteriorates the trade balance, but it improves in the long-run. The author's results provide support for the J-curve effect.

## Theoretical framework

Following Rose and Yellen (1989), the trade balance behaviour of a country can be modelled as a function of the real exchange rate and the real domestic and foreign incomes.

The model starts with the standard specifications of the exports and imports demand functions. Exports are a positive function of foreign income and the nominal exchange rate while imports are a negative function of the nominal exchange rate and a positive function of domestic income. The specific demand functions are as follows:

$$X_t = \left[\frac{P}{P^*E}\right]_t^{\lambda} . (Y_t^*)^{\alpha} \quad \text{.........(1)}$$

$$M_t = \left[\frac{P^*E}{P}\right]_t^{\mu} . (Y_t)^{\delta} \quad \text{.........(2)}$$

where X and M are the volumes of exports and imports, respectively. E denotes the nominal exchange rate, which is defined as the domestic currency price of foreign currency. P and P* denote the domestic and foreign price levels, respectively. Y and Y* are the respective domestic and foreign income levels. The parameters λ and μ are the real exchange rate elasticities for exports and imports, and α and δ are the respective income elasticities for exports and imports.

Taking natural logarithms for equations (1) and (2) we get

$$lnX_t = \lambda[lnP_t - lnP_t^* - lnE_t] + \alpha lnY_t^* \quad \text{.........(3)}$$

$$lnM_t = \mu[lnP_t^* + lnE_t - lnP_t] + \delta lnY_t \quad \text{.........(4)}$$

where $lne_t = [lnP^*_t + lnE_t - lnP_t]$ is the natural log of the real exchange rate. Denoting trade balance by TB, which is defined asthe ratio between exports and imports (note that Bahmani-Oskooee and Gelan (2012) define the trade balance as the inverse of the way we define it) so

$$lnTB_t = \delta lnY_t + \alpha lnY_t^* + \pi lne_t \text{..........................................................}(5)$$

Where $\pi$ = -(λ +μ). The parameters λ and μ are assumed to be negative and α and δ are expected to be positive. The coefficient of $lne_t$ shows whether the ML condition is satisfied or not. Thus, the ML condition holds whenever π is positive, indicating that a higher real exchange rate, that is, a real depreciation, appears to improve the trade balance over time.We are concerned with estimating the time-path of the trade balance in response to changes in the exchange rate of the South African currency.

## Econometric Methodology

### Cointegration

Following Halicioglu (2008) we follow the non-structural, partial reduced form model of Rose and Yellen (1989), which is specified as:

$$lnTB_t = \beta_0 + \beta_1 lnDY_t + \beta_2 lnWY_t + \beta_3 lnREER_t + \varepsilon_t \text{ ..................}(6)$$

Where TB is our measure of the real trade balance,which is defined as the ratio of South African exportsto imports; DY is the measure of domestic income which is proxied by theindustrial production index of South Africa; WY is the measure of world income which is proxied by the industrial production index of industrial countries; REER is the real effective exchange rate.

There are no *apriori* expectations on the signs of $\beta_1$ and $\beta_2$. However, $\beta_3$ is expected to be positive if real depreciation is to improve the trade balance in the long-run.

Equation (6) outlines the long-run relationship among the variables in the model. To test whether there exists a long-run relationship among the variables we employ the bounds test (autoregressive distributed lag, ARDL) approach that was initiated by Pesaran et al. (2001). The test involves the estimation of the following unrestricted error correction model (UECM):

$$\Delta lnTB_t = \beta_0 + \sum_{k=1}^{m} \beta_{1k} \Delta lnTB_{t-k} + \sum_{k=0}^{m} \beta_{2k} \Delta lnDY_{t-k} + \sum_{k=0}^{m} \beta_{3k} \Delta lnWY_{t-k} + \sum_{k=0}^{m} \beta_{4k} \Delta lnREERX_{t-k} + \lambda_1 lnTB_{t-1} + \lambda_2 lnDY_{t-1} + \lambda_3 lnWY_{t-1} + \lambda_4 lnREER_{t-1} + \mu_t \text{ ......................................................}(7)$$

Here Δ is the first difference operator;$\mu_t$ is an error termand the other variables are as defined before. The *F* test proposed by Pesaran *et al*. (2001) can be used to determine whether a long-run relationship exists through testing the significance of the lagged levels of the variables. If such a relationship exists among the variables, the *F* test indicates which variable should be normalized.

The bounds test methodology suggests analysing the null hypothesis of no co-integration through a joint significance test of the lagged levels of the variables. The null hypothesis of no co-integration among the variables in Equation (2) is ($H_0$: $\lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = 0$) against the alternative hypothesis ($H_1$: $\lambda_1 \neq 0$, or $\lambda_2 \neq 0$, or $\lambda_3 \neq 0$, or $\lambda_4 \neq 0$).

The paper tests the null hypothesis of no co-integration by means of the *F*-test. Pesaran et al. (2001) have established that, under the null hypothesis of no co-integration and regardless of the degree of integration of the variables, the asymptotic distribution of the obtained *F*-statistic is non-standard. It follows an asymptotic $\chi^2(m)$ under the null, where m is the number of restrictions. They develop two bounds of critical values for the different model specifications: upper bound applies when all variables are integrated of order one, I(1) and the lower bound applies when all the variables are stationary, I(0). However, these critical values are generated on sample sizes of 500 and 1000 observations and 20 000 and 40 000 replications, respectively. Narayan and Narayan (2005) argue that such critical values cannot be used for small sample sizes like the one in this study. Given the relatively small sample size in the present study (40 observations) the paper extracts the appropriate critical values from Narayan (2005) which were generated for small sample sizes of between 30 and 80 observations.

If the computed *F*-statistic, for a chosen level of significance, lies outside the critical bounds, a conclusive decision can be made regarding co integration without knowing the order of integration of the regressors. If the estimated test statistic is higher than the upper bound, the null hypothesis of no co-integration is rejected. If the *F*-statistic is lower than the lower bound then the null hypothesis cannot be rejected. If the *F*-statistic lies between the lower and the upper bounds, conclusive inference cannot be made. By adopting Pesaran et al.’s (2001) approach for co-integration analysis, a pre-test for unit root (degree of integration) of the series is not necessary.

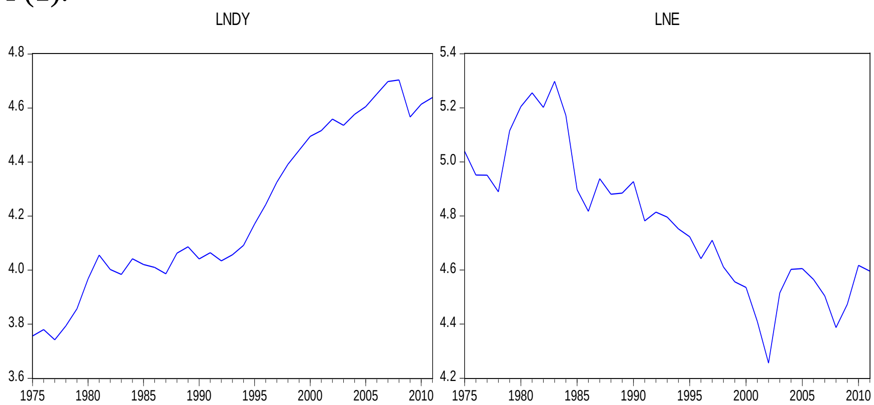
The chosen methodology, which is based on the estimation of an unrestricted error-correction model (UECM), has certain preference over other co integration tests. First, Pattichis, (1999: 1062) argues that the UECM is likely to have better statistical properties because it does not push the short-run dynamics into the residual term as in the Engle-Granger (1987) technique. Second, it can be applied to studies that have finite samples unlike the Engle and Granger (1987) approach, which suffers from considerable small sample bias (Mah, 2000: 240). Third, the bounds test procedure is applicable irrespective of whether the underlying explanatory variables are integrated of order zero (I (0)) or one (I (1)) (Mah, 2000: 240). In other words, it avoids the pre-testing problems associated with standard co-integration analysis which requires the classification of variables into I(0) and I(1) (Pesaran et al., 2001). Fourth, another important advantage of the bounds test procedure is that estimation is possible even when the explanatory variables are endogenous, and is sufficient to simultaneously correct for residual serial correlation. However, it has to be pointed out that this procedure (method) is inappropriate if there is more than one co integrating relationship involving the dependent variable.

## Empirical Results

### Data and the time series properties

Annual data for the period 1975-2011 is used in this study. Trade balance is defined as the ratio of goods exports to goods imports (both measured in millions of US dollars, free on board). Domestic income is proxied by South Africa's manufacturing production index with base year 2005. World income is proxied by the industrial production index for industrial countries, also with base year 2005. All the data were obtained from the International Financial Statistics (IFS) published by the International Monetary Fund. All variables are expressed in natural logarithms.Figure 1 plots the individual time series of the data employed in this study in their natural logarithms.

A stationary series is characterized by a time-invariant mean and a time-invariant variance. There are alternative methods that are used to test for non-stationarity of a time series. The traditional methods (augmented Dickey-Fuller and Phillips-Perron tests) have been criticized for having low power (Abdulnasser and Manuchehr, 2002). In this study we use the Dickey-Fuller GLS test to examine the unit root properties of the data. The results reveal that the null hypothesis of unit root is not rejected in levels for all variables, but is rejected in first differences. A constant and trend were included in these tests. Table 1 presents the DF-GLS unit root test results. The unit root test results show that all the variables are integrated of order one, I (1).



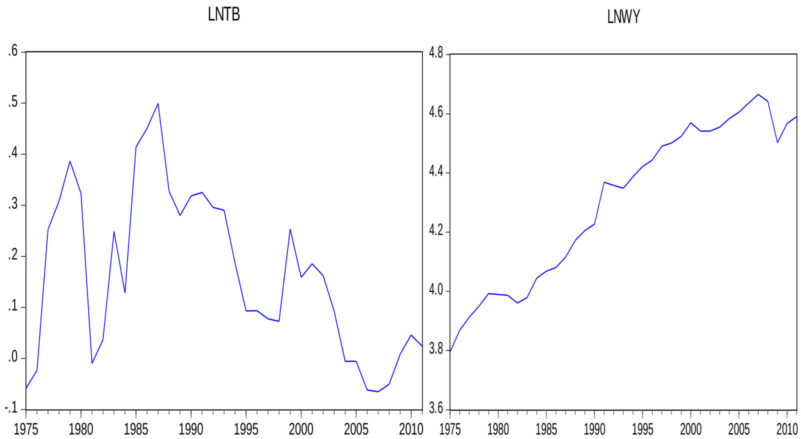



Figure 1.Plot of time series in natural logarithms

Table 1. Unit root test results: DF-GLS

| Variable | levels | First difference |
|---|---|---|
| lnREER | -2.383 (-2.890) | -5.400***(-3.770) |
| lnDY | -1.774 (-2.890) | -5.043***(-3.190) |
| lnWY | -1.440 (-2.890) | -4.903***(-3.770) |
| lnTB | -2.651 (-2.890) | -6.098***(-3.770) |

*** denote rejection of a unit root null hypothesis based on MacKinnon's critical value at 1%. The numbers in the parentheses for the levels are the critical values at 10% level.

## Cointegration test results

Table 2 presents the results of the estimation of an unrestricted error correction model (UECM) of equation (7). The optimal lag length (n) for the UECM is selected using the Akaike information criterion (AIC). The general UECM is tested downwards sequentially to arrive at a parsimonious equation. By comparing the calculated *F*-statistic to the critical values we can see that the null hypothesis of no long-run relationship is rejected in the case where trade balance is the dependent variable. The calculated *F*-statistic of 5.827 is greater than the upper bound of 4.803 at 5% level. The unique cointegrating relationship among these variables is also confirmed by the multivariate Johansen-Juselius approach to cointegration.

Table 2. Bounds testing procedure results

| Dependent variable | *F*-statistic | Critical bounds at 5% | |
|---|---|---|---|
| | | Lower bound I(0) | Upper bound I(1) |
| $F_{TB}$(TB/ DY, WY, REER) | 5.827** | 3.548 | 4.803 |

** denotes statistical significance at 5% level.

Number of regressors = 3. Critical values are obtained from Narayan (2005) for 40 observations; case III is for unrestricted intercept and no trend.

In the last step we address is related to the goodness of fit of our UECM model. The parsimonious model passes a battery of diagnostic and stability tests (which are not reported here). These include the examination of serial correlation using the Lagrange multiplier test for serial correlation, the Jarque-Bera test for normality of the residuals, ARCH test for heteroscedasticity, Ramsey reset for functional form.

## Empirical Results

Table (3) presents the results of the long-run coefficient estimates using the autoregressive distributed lag approach. The order of the lags was obtained by means of Akaike Information Criterion (AIC) and the Schwartz Bayesian Criterion (SBC), which indicated that the optimal lag level as four and one, respectively for this study. Considering the long-run coefficients one concludes that the AIC-based trade balance model seems to be a better fit than the SBC model since the coefficients of the former model are statistically significant at the 1% level. From Table (3), we can see that the real effective exchange rate carries a negative sign but is statistically insignificant in both models. This result indicates that the real effective exchange rate does not play a significant role in the trade balance in the long-run. According to both models domestic and foreign incomes have, respectively, negative and positive impacts on the trade balance. Both domestic and foreign incomes are statistically significant in the model according to the AIC selection. These signs are what will be expected according to economic theory when the demand side dominates. Our results according to the AIC selection indicate that a 10 percent increase in domestic income leads to a 13.86 percentage decrease in the trade balance. A 10 percent increase in world income results in 13.2 percentage increase in the trade balance.

Table 3. Long-run coefficients of South Africa's trade balance

| Regressors | AIC ARDL (4, 1, 3, 4) | SBC ARDL (1, 1, 1, 0) |
|---|---|---|
| lnDY | -1.386*** (3.880) | -1.111*** (2.935) |
| lnWY | 1.320*** (3.273) | 0.378 (0.844) |
| lnREER | -0.162 (0.942) | -0.194 (1.524) |
| Constant | 3.463 (1.542) | 2.294 (2.030) |

Notes: The absolute value of the *t-ratios* is in the parentheses. *** indicate statistical significance at 1% level.

Since the J-curve is a short-run phenomenon, we estimate the short-run coefficients of the real effective exchange rate using a restricted error correction model. This follows earlier studies by Halicioglu (2009) and Perera (2009). The model is estimated using the AIC lag selection and includes the error correction term $EC_{t-1}$, which comes from the cointegrating vector.

Table (4) presents the coefficient estimates of the current and lagged first-differenced real effective exchange rate to investigate the J-curve effect. The result indicates evidence for negative values in earlier quarters followed by positive values later as the lag length increases. However, only one coefficient of lagged difference of the real effective exchange rate is significant. Also these negative short-run effects do not translate into a positive long-run impact on the trade balance. Therefore the J-curve phenomenon is not supported.

Table 4. Coefficient estimates of $\Delta$ $lnREER_{t-i}$ and error correction term

| Regressor | Coefficient | t-statistic |
|---|---|---|
| Dependent variable $\Delta lnTB_t$ | | |
| $\Delta lnREER_t$ | -0.151 | 0.866 |
| $\Delta lnREER_{t-1}$ | -0.366** | 2.303 |
| $\Delta lnREER_{t-2}$ | -0.131 | 0.732 |
| $\Delta lnREER_{t-3}$ | -0.056 | 0.326 |
| $\Delta lnREER_{t-4}$ | 0.159 | 0.918 |
| $EC_{t-1}$ | -0.391** | 2.180 |
| Adj $R^2$ | 0.240 | |
| Diagnostic statistics | | |
| $\chi^2_{SC}(2) = 0.147$; $\chi^2_{FC}(1) = 0.05$; $\chi^2_{N}(2) = 0.010$; $\chi^2_{H}(1) = 0.125$ | | |
| CUSUM: Unstable<br>CUSUMSQ: Stable | | |

Notes: *t-ratios* are in absolute values, $\chi^2_{SC}$; $\chi^2_{FC}$; $\chi^2_{N}$; and $\chi^2_{H}$are Lagrange multiplier statistics for tests for residual correlation, functional form mis-specification, nonnormal errors and heteroscedasticity, respectively. These statistics are distributed as Chi-squared variates with degrees of freedom in parentheses.
** indicate statistical significance at the 5% level.

The parameter stability was tested using equation (7). Equation (7) was estimated by ordinary least squares with a lag length of 2 based on the Akaike Information Criterion. Figures 2 and 3 provide the plots of the CUSUM and CUSUMSQ tests, respectively. The two tests present conflicting results with regards to parameter stability. The CUSUM test shows that parameters are stable as indicated by the fact that the plot lies within the 5 percent bounds. On the other hand the CUSUMSQ test indicates that there is parameter instability.

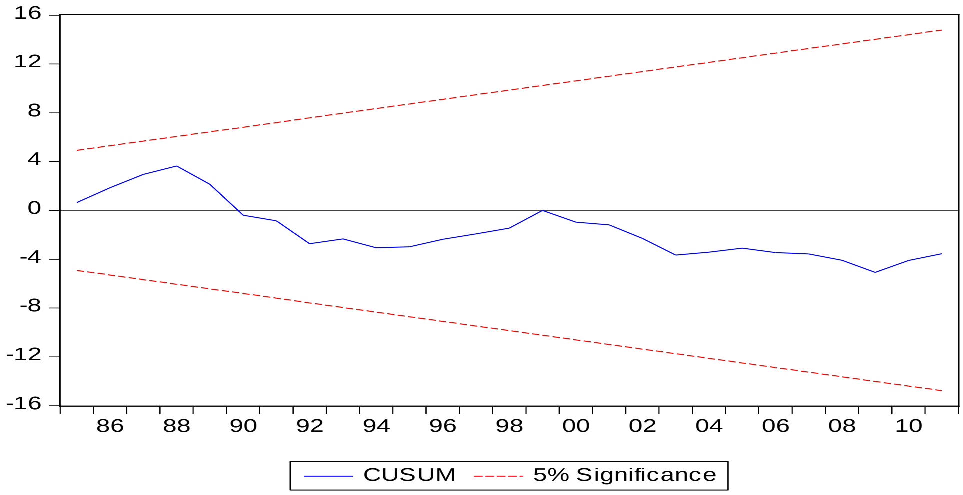


Figure 2. Plot of CUSUM

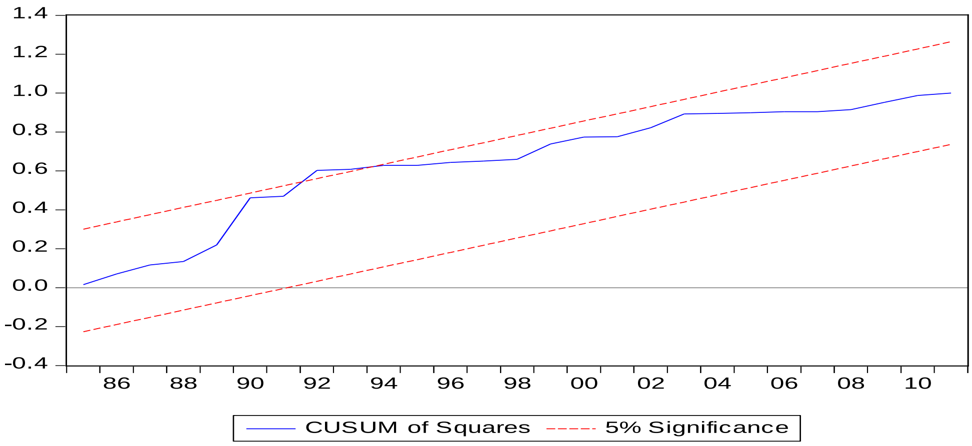


Figure 3. Plot of CUSUMSQ

**Concluding remarks**

The objective of this paper was to test the J-curve hypothesis for South Africa using aggregate trade data for the period 1975 to 2011. This objective was achieved by employing the ARDL bounds testing approach to cointegration and error correction modelling. Our bounds test results indicate that there is a long-run relationship between the trade balance and the real effective exchange rate, and domestic and foreign income.

Our long-run results are estimated using two models based on the selection of the optimal lag. The two models are based on the Akaike Information Criterion (AIC) and the Schwartz Bayesian Criterion (SBC). Considering the long-run coefficients one concludes that the AIC-based trade balance model seems to be a better fit than the SBC model since the coefficients of the former model are statistically significant at the 1% level.

Our long-run results indicate that the real effective exchange rate carries a negative sign but is statistically insignificant in both models. This result indicates that the real effective exchange rate does not play a significant role in the trade balance in the long-run. According to both models domestic and foreign incomes have, respectively, negative and positive impacts on the trade balance. Both domestic and foreign incomes are statistically significant in the model according to the AIC selection. These signs are what will be expected according to economic theory when the demand side dominates. Our results according to the AIC selection indicate that a 10 percent increase in domestic income leads to a 13.86 percentage decrease in the trade balance. A 10 percent increase in world income results in 13.2 percentage increase in the trade balance.

In order to assess the J-curve which is a short-run phenomenon, we estimate the short-run coefficients of the real effective exchange rate using a restricted error correction model. The result shows evidence for negative values in earlier quarters followed by positive values later as the lag length increases but most of them are insignificant. The insignificance of these coefficients together with the fact that the real effective exchange rate has a negative long-run impact on the trade balance, means that the J-curve is not supported by our results. The parameter stability tests on the long-run trade balance equation appear to be inconclusive.

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